Technology Opportunity

Computer Simulation of Turbulent Spray Flames

A computer software program has been developed to model the turbulent spray flames occurring in a wide range of practical combustion devices. Conventional turbulence closure models have difficulty treating the complex chemistry-turbulence interactions encountered in flows of practical interest. This procedure, which is based on the coupled Monte Carlo PDF/SPRAY/CFD (probability density function/SPRAY/computational fluid dynamics) computations, has an advantage in that it treats the nonlinear chemical reaction rates without any approximation. The recently developed computer software offers the novelty of the coupled PDF/SPRAY/CFD computations and the capability of being run on parallel computers. The computations represent the current state of the art in reactive flow computations.

Potential Commercial Uses

• Computer-aided design of practical combustion devices (aircraft engines and power-plant furnaces)
• Design of improved, fuel-efficient combustors
• Assessment of new fuels for combustor application
• Design of spray equipment
• Next generation aircraft engines requiring stringent emissions-control

Benefits

• Does not approximate nonlinear reaction rates (unlike conventional software)
• Offers greater potential in the prediction of emissions and combustor extinction and blowoff limits
• Provides an understanding of global flow properties (temperature, velocity, and species), spray evaporation and spreading rates, and combustor-liner heat transfer rates

The Technology

The success of any solution methodology used in the study of practical combustion devices depends a great deal on how well it models various complex and rate-controlling processes associated with turbulent transport, chemical kinetics, evaporation and spreading rates of the spray, and radiative heat transfer. These phenomena often strongly interact with each other at disparate time and length scales. Turbulence, in particular, plays an important role in determining the rates of mass and heat transfer, chemical reactions, and spray evaporation. The present method holds the promise of modeling various important combustion phenomena such as flame extinction and blowoff limits, as well as emissions predictions, as it treats the nonlinear chemical reaction rates without approximation.
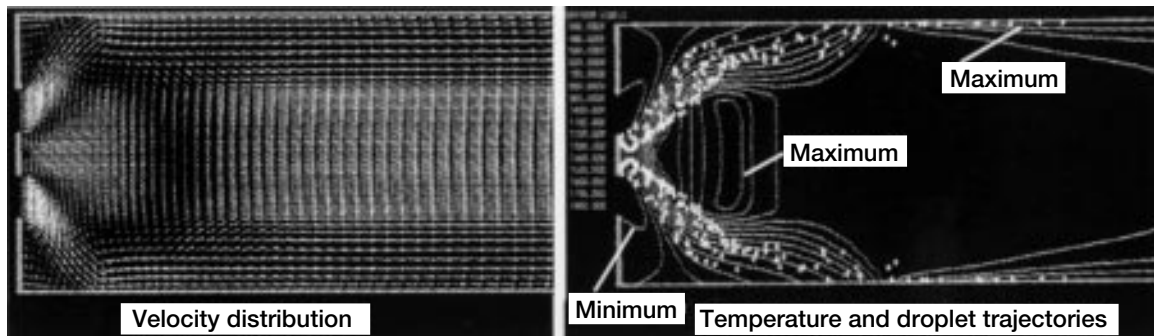
Predicted flow features of a swirl-stabilized can combustor.

Options for Commercialization

The PDF and SPRAY codes were developed through a collaborative effort between NASA Lewis Research Center and NYMA, Inc. The computations were performed by coupling the PDF and SPRAY codes with CONCERT-3D, a CFD code of GE Aircraft Engine Company. The PDF and SPRAY modules can be released to the public after they are coupled with a nonproprietary CFD code available at NASA Lewis. Researchers are interested in a collaborating to further extend the software over a wide range of fuel-specific chemical kinetic mechanisms that are of interest to potential users.

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